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UTILISATION OF PALM OIL MILL EFFLUENT AS NITROGEN SOURCE FOR OIL PALM (ELAEIS GUINEENSIS JACQ.)

MOHAMAD HASHIM BIN AHMAD TAJUDIN

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By

MOHAMAD HASHIM BIN AHMAD TAJUDIN

Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Agricultural Science in the Faculty of Agriculture
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Specially dedicated to:

my wife	-	*Lailaton Abd Rahman*
and my children	-	*Norsyimalaila*
	-	*Norfaeza*
	-	*Nor Adila*

Whose love, understanding and support have greatly helped me in the completion of this thesis.

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LIST OF ABBREVIATIONS

a.e.	atom excess
ANOVA	Analysis of Variance
A-POME	A-value of POME
BOD	Biochemical Oxygen Demand
CEC	Cation Exchange Capacity
COD	Chemical Oxygen Demand
CIRP	Christmas Island Rock Phosphate
C/N	Carbon to Nitrogen ratio
FFB	Fresh Fruit Bunch
Golden Hope	Golden Hope Plantations Berhad
LSD	Least Significant Difference
MOP	Muriate of Potash
NdfF	Nitrogen derived from Fertilizer
NdfS	Nitrogen derived from Soil
NdfPOME	Nitrogen derived from Palm Oil Mill Effluent
OPRS	Oil Palm Research Station
POME	Palm Oil Mill Effluent
RCBD	Randomised Complete Block Design

ABSTRACT

Abstract of thesis submitted to the Senate of Universiti Pertanian Malaysia in partial fulfilment of the requirements for the degree of Master of Agricultural Science

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May 1990

Supervisor: Associate Professor Dr. Zaharah Abd. Rahman

Faculty : Agriculture

Palm oil mill effluent (POME) is an organic waste material produced at the oil mill. In its raw form, POME is highly polluting. It must be treated before being discharged into the waterways. But in view of its high nutrient content, it can be recycled to the soil as a fertilizer for agricultural crops.

In this study, three series of experiments were conducted. First, a laboratory incubation study aimed at determining the rate of nitrogen mineralisation of treated POME. Second, nursery trials with the objective of quantifying the amount of nitrogen availability in treated POME using N-15 tracer technique. Third, a field trial with

the aim of evaluating the effectiveness of effluent as a nitrogen fertilizer for mature oil palm.

Results of the incubation study indicated that ammonium-N was made available almost immediately after application. Its release recorded a slight increase at the fourth week and thereafter stabilised with time. The trend was different for nitrate-N. Its release was negligible at the initial period, but increased significantly after eight weeks of incubation. This is an indication of nitrification process occurring in the soil in which ammonium-N was converted to nitrate-N.

In the nursery trial, the amount of nitrogen released and taken up by oil palm seedlings depended very much on the nitrogen content of the treated POME. At 2254 mg kg^{-1} nitrogen content, about 1.253 g N in equivalent unit of ammonium sulphate was made available almost immediately after application for a period of two months. At a higher content of 4851 mg kg^{-1}, the rate of nitrogen release peaked at one month after application in which 8.355 g N in equivalent unit of ammonium sulphate was made available for plant uptake. The amount of POME-N taken up by oil palm seedlings was again related to the nitrogen content of treated POME. At low level of nitrogen content about 0.165 g N in equivalent unit of ammonium sulphate was taken up while at high nitrogen content the uptake was 0.401 g N thus giving utilisation efficiency of 7.3% and 8.3% respectively.

In the field trial, the effectiveness of treated POME as a source of nitrogen was confirmed. Its application at appropriate rate was observed to be able to support satisfactory palm growth and crop production. In addition, soil chemical properties were also improved.

From the results of these trials, it is concluded that treated POME is just as effective as inorganic fertilizer in supplying nitrogen for oil palm planted on Selangor series soil.

ABSTRAK

Abstrak tesis yang dikemukakan kepada Senat
Universiti Pertanian Malaysia sebagai memenuhi
sebahagian daripada syarat-syarat untuk
Ijazah Master Sains Pertanian

PENGGUNAAN EFLUEN KILANG MINYAK SAWIT SEBAGAI SUMBER NITROGEN UNTUK KELAPA SAWIT (ELAEIS GUINEENSIS JACQ.)

Oleh

MOHAMAD HASHIM BIN AHMAD TAJUDIN

Mei 1990

Ketua Penyelia: Profesor Madya Dr. Zaharah Abd. Rahman

Fakulti : Pertanian

Efluen kilang minyak sawit (POME) ialah satu bahan buangan organik yang terdapat di kilang-kilang. Dalam keadaan asalnya, POME boleh mencemarkan alam sekitar. Dengan sebab itu, ianya perlu dirawat sebelum disalurkan ke sungai. Tetapi memandangkan kepada kandungan unsur nutrien yang tinggi di dalam POME, ianya boleh digunakan sebagai baja untuk tanaman pertanian.

Dalam kajian ini, tiga siri percubaan telah dijalankan. Pertama, percubaan pengeraman di makmal yang bertujuan untuk menentukan kadar mineralisasi nitrogen yang terdapat di dalam POME. Kedua, percubaan di tapak semaian untuk menentukan kedapatan nitrogen

di dalam POME menggunakan kaedah pencairan isotop N-15. Ketiga, percubaan di ladang untuk menguji keberkesanan POME sebagai baja organik untuk kelapa sawit.

Keputusan kajian pengeraman menunjukkan bahawa nitrogen dalam bentuk ammonium menjadi tersedia selepas disiram ke tanah. Mineralisasi ammonium-N meningkat sedikit pada minggu keempat dan kemudiannya stabil pada peringkat yang rendah sedikit. Corak mineralisasi nitrate-N berlainan pula. Pada peringkat awal pengeraman, mineralisasi nitrate-N adalah terlalu rendah tetapi meningkat dengan bererti selepas lapan minggu. Ini menunjukkan terdapatnya proses nitrifikasi di dalam tanah di mana ammonium-N ditukarkan ke nitrate-N.

Dalam percubaan di tapak semaian, jumlah nitrogen tersedia dan diserap oleh anak kelapa sawit adalah bergantung kepada kandungan nitrogen di dalam efluen terawat. Pada kandungan nitrogen 2254 mg kg^{-1}, lebih kurang 1.253 g N dalam unit persamaan ammonium sulfat telah tersedia selepas sahaja disiram selama dua bulan. Pada kandungan nitrogen yang tinggi iaitu 4851 mg kg^{-1}, kadar pembebasan nitrogen memuncak pada satu bulan selepas disiram dengan 8.355 g N dalam unit persamaan ammonium sulfat tersedia untuk diserap oleh pokok. Kuantiti POME-N yang diserap oleh anak kelapa sawit juga berkait rapat dengan kandungan nitrogen di dalam efluen terawat. Pada kandungan nitrogen yang rendah, sebanyak 0.165 g N dalam unit persamaan ammonium sulfat telah diserap, manakala pada kandungan nitrogen yang tinggi penyerapan adalah sebanyak 0.401 g N menjadikan kecekapan penggunaan masing-masing pada tahap 7.3% dan 8.3%.

Dalam percubaan di ladang, keputusan yang didapati telahpun menunjukkan keberkesanan POME sebagai punca nitrogen. Pemberian POME kepada pokok kelapa sawit dengan kadar tertentu telah menunjukkan keupayaannya untuk menampung pertumbuhan pokok dan hasil pada tahap yang memuaskan. Di samping itu, sifat kimia tanah juga telah dipertingkatkan.

Berdasarkan kepada keputusan yang diperolehi, maka bolehlah dibuat kesimpulan bahawa POME berupaya memberikan unsur nitrogen sama seperti baja bukan organik kepada kelapa sawit yang ditanam di kawasan tanah siri Selangor.

CHAPTER I

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is the world's most rapidly expanding plantation crop over the past two decades and it has become one of the most important sources of vegetable oils and fats, contributing about 15% of the world's supply in which Malaysia is the biggest producer. Its cultivated area in Malaysia is expanding further with the opening up of new areas and rehabilitation of idle land. This is in line with the National Agriculture Policy which aims at maintaining the country as the number one producer of palm oil.

The rapid expansion of oil palm industry in Malaysia has resulted in an increase of crude palm oil production from about 431,000 tonnes in 1970 to 5 million tonnes in 1988. Its production is projected to increase further to about 5.5 million tonnes in 1990 and 8.1 million tonnes in the year 2000. With such large production of palm oil there would also be abundant by-products and residues. One of the major by-products produced is palm oil mill effluent (POME). In 1981, 7.5 million tonnes of POME was generated and this is expected to double in 1990. Discharging raw waste material into waterways is a threat to the environment because of the high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) content (Yeow, 1983). The government has since enforced the Environmental Quality Act which requires that raw POME be treated to an acceptable level before it is discharged.

However, POME could be put into good use in view of its high nutrient value. Many research findings have shown that various types of waste materials are good source of plant nutrients. Their application to land as fertilizer supplement for crops was found to be beneficial to crop performance and soil physical and chemical characteristics (Khaleel et al., 1981; Demuynck et al., 1984; Ghederim et al., 1985; Titloye et al., 1985).

Some studies have been carried out on utilisation of POME and its effect on crop and soil properties. However, little attention had been given to the research works aimed at quantifying the amount of nutrients released by POME for plant uptake. Though POME contains other major plant nutrients, this study emphasises on nitrogen in view of its high composition in the effluent. The objectives of the study were therefore,

(i) To determine the mineralisation rate of nitrogen in treated POME.

(ii) To quantify the amount of nitrogen derived from treated POME.

(iii) To evaluate the effectiveness of treated POME as fertilizer source for oil palm growth and yield.

CHAPTER II

LITERATURE REVIEW

Nitrogen Requirement of Oil Palm

Nitrogen is an essential constituent of protein, nucleic acids and various enzymes. Most of the biochemical reactions in the palm are catalysed by enzymes and thus nitrogen plays an important function virtually in all physiological processes (Frank, 1965). In situations where nitrogen is deficient, chlorosis of leaves occurs which leads to reduced rate of photosynthesis. Reduced protein synthesis also occurs resulting in general loss of vigour. In experiment where severe nitrogen deficiency was induced on oil palm seedlings, leaf chlorophyll content was greatly reduced and photosynthetic rate was also lowered (Corley, 1976).

In oil palm, nitrogen fertilizer application had been shown to increase leaf area, leaf weight, rate of leaf production and net assimilation rate (Corley and Mok, 1972). Its application had also been shown to increase fresh fruit bunch (FFB) yield on both inland and coastal soils (Teoh and Chew, 1980; Chan, 1981; Tan *et al*., 1981; Sinasamy *et al*., 1982; Lim *et al*., 1984).

In coastal clay soil such as Selangor series (*Aeric Tropaquept*) the main response was to nitrogen even though the fertility of this soil is considered to be higher than most of the other soils in Peninsular Malaysia (Foster and Goh, 1977; Teoh and Chew, 1980; Foster et al., 1985). Similar response was also obtained in the leaf nitrogen content (Piggott, 1968; Teoh and Chew, 1980).

Soil Nitrogen and Organic Matter Status

Generally, Malaysian soils are poor in nutrient status. They are heavily leached, acidic, low in exchangeable bases, base saturation percentage and also low in cation exchange capacity (Law and Tan, 1977). In areas where plantation crops have been grown for two to three generations, most of the inherent soil nutrients and organic matter are exhausted. The estimated quantity of nitrogen in some of the common Malaysian soils under plantation was found to be ranging from 2720 to 22180 kg ha^{-1} (Pushparajah, 1982). Oil palm in particular, utilises large amounts of nutrients in order to sustain high crop production. It was estimated that the total requirement of nitrogen from the first to the fifteenth year which is the most active growing period of the palm, amounted to about 2455 kg N ha^{-1} (Ng, 1972). With this assumption, the nitrogen present in most Malaysian soils (Table 1) is insufficient to satisfy the needs of the crop (Pushparajah, 1982).

Organic matter is one of the most important constituents of soil which influences many physical, chemical and biological properties. It therefore plays an important role in improving the overall fertility of soil, particularly the highly leached Malaysian soils

Table 1

Estimates of Total Soil Nitrogen in the
Top 45 cm of Profile

Soil Series	Soil Order	Range of N (kg ha^{-1})[a]
Rengam	Ultisol	4190 - 11300
Serdang	Ultisol	4090 - 10690
Durian	Ultisol	2720 - 13870
Malacca	Oxisol	2800 - 10100
Holyrood	Entisol	5150 - 13560
Selangor	Inceptisol	4650 - 22180

Source

a : Pushparajah, 1982

(Othman et al., 1979). The average organic matter content of soil planted with plantation crops was observed to be 4.01% and 2.50% in the 0-6 and 6-15 cm depth respectively with corresponding nitrogen content of 0.16% and 0.10% (Coulter, 1950). It is because of this highly beneficial effect of organic matter that leguminous ground covers are established in plantations to improve and maintain soil fertility. Establishment of leguminous cover crops had been shown to contribute about 900 kg ha^{-1} of nitrogen (Tajudin et al., 1980). Its establishment had also been shown to significantly increase FFB yield in oil palm plantation (Gray and Hew, 1968).

Application of palm oil mill effluent was also found to improve the organic matter and nitrogen status of soil (Poon, 1982; Lim et al., 1983; Lim, 1987). Application of cattle slurry and sewage sludge were observed to have similar beneficial effects (Demuynck et al., 1984; Lindermann and Cardenas, 1984; Garau et al., 1986).

Types of POME

In the milling of fresh fruit bunches at the oil mill, there are three main waste products that contribute to the final discharged effluent (Ma et al., 1982). They are:

(i) Steriliser condensate which is the waste discharge of the sterilisation process.

(ii) Hydrocyclone waste which is produced from the kernel separating process.

(iii) Sludge waste which is produced at the separating process of the oil liquor. This waste is also termed as centrifugal sludge.

These three wastes form the final discharge which is called raw effluent. Diagrammatic flow chart of palm oil extraction process and waste production is shown in Figure 1.

Average production of these wastes is about 13.6 mt ha^{-1} (Chan et al., 1980) or about 2.5 mt effluent per tonne of palm oil produced